DOE/OE Transmission Reliability Program

Damping Inter-area Oscillations through Decoupled Modulation

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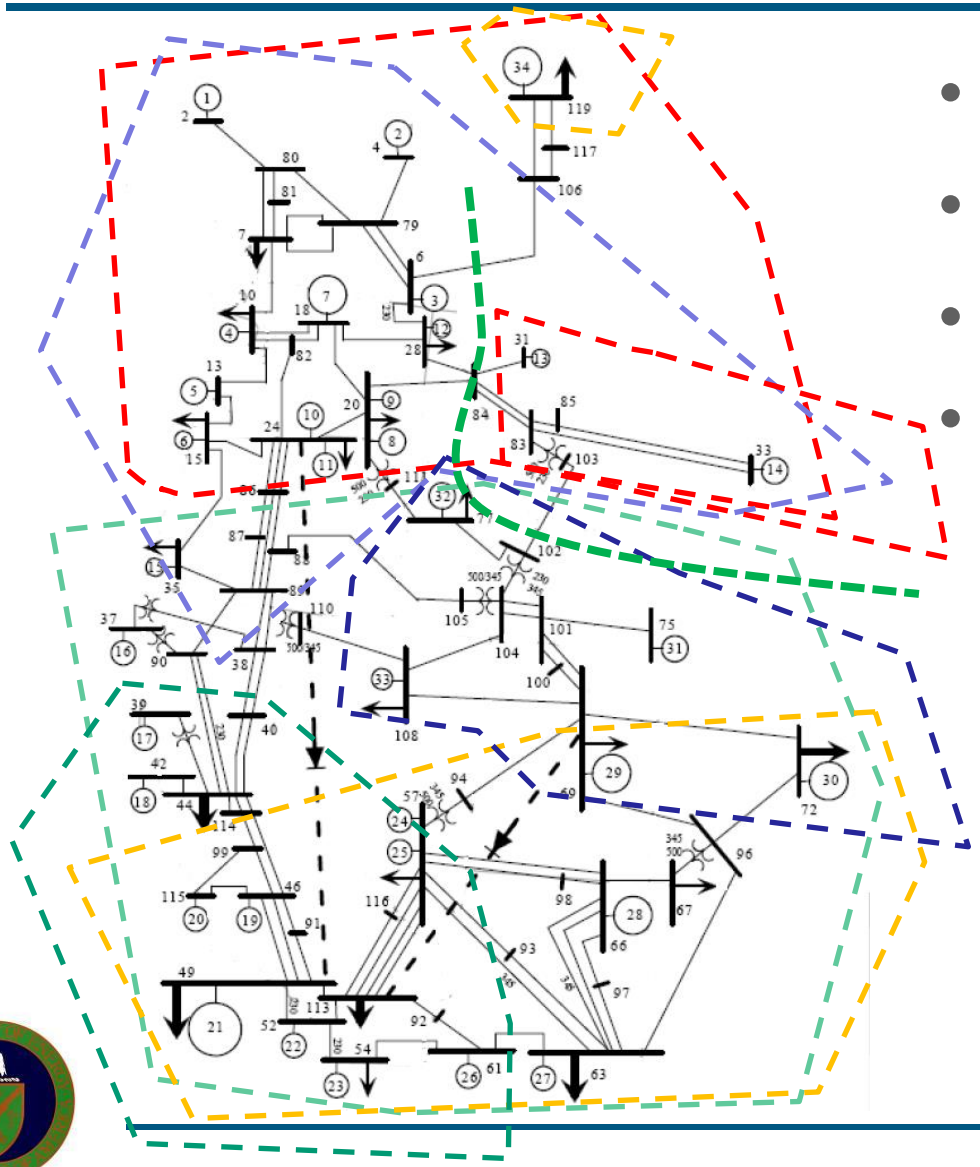
Complex interactions of multiple inter-area oscillation modes

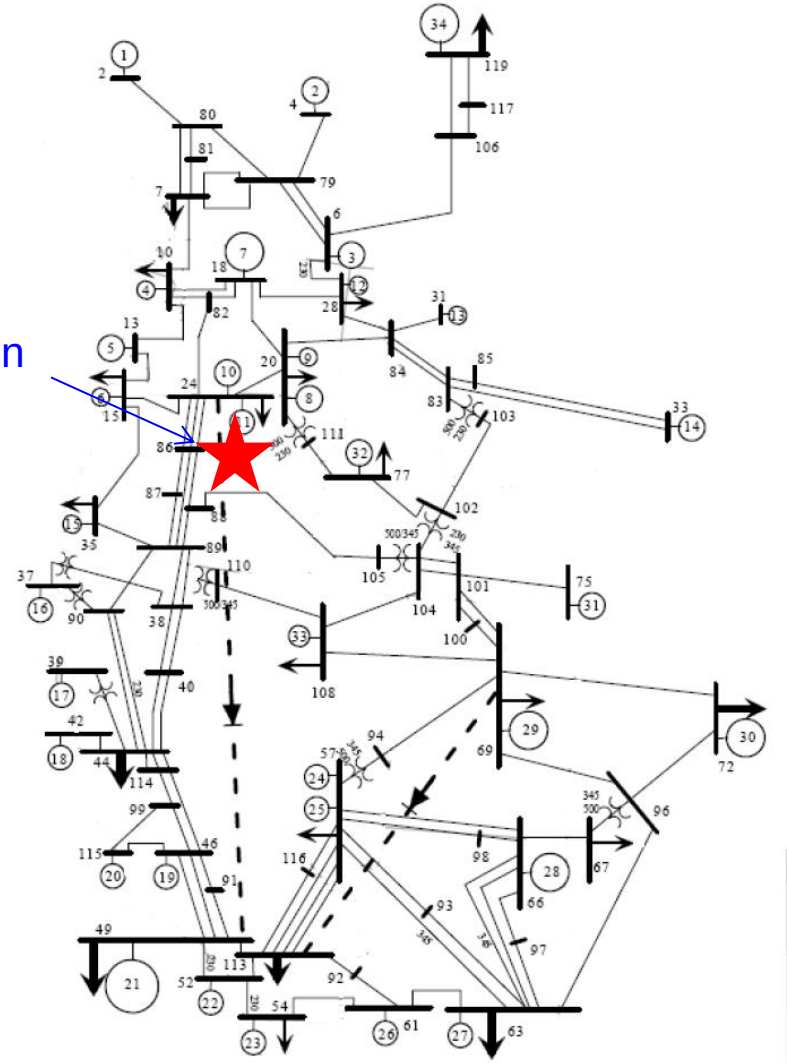


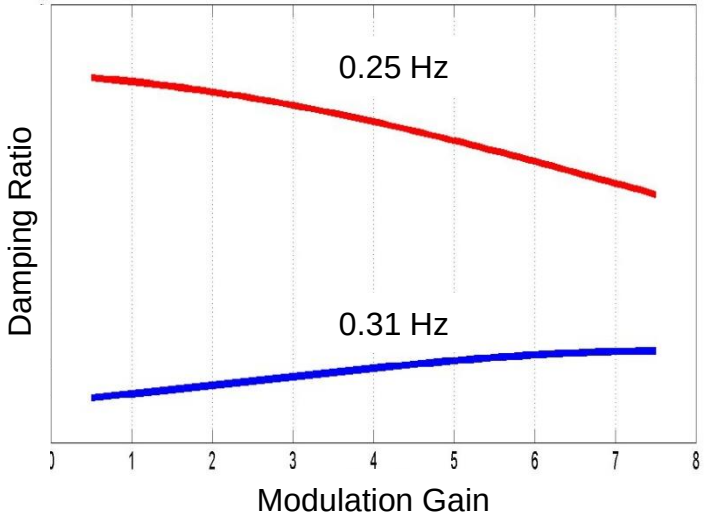
- 0.17 Hz N-S mode
- 0.32 Hz Alberta mode
- 0.5 Hz E-W mode
- 0.55 Hz Montana mode

Credit: Dan Trudnowski

Controller design facing interference between oscillation modes

Modulation Control



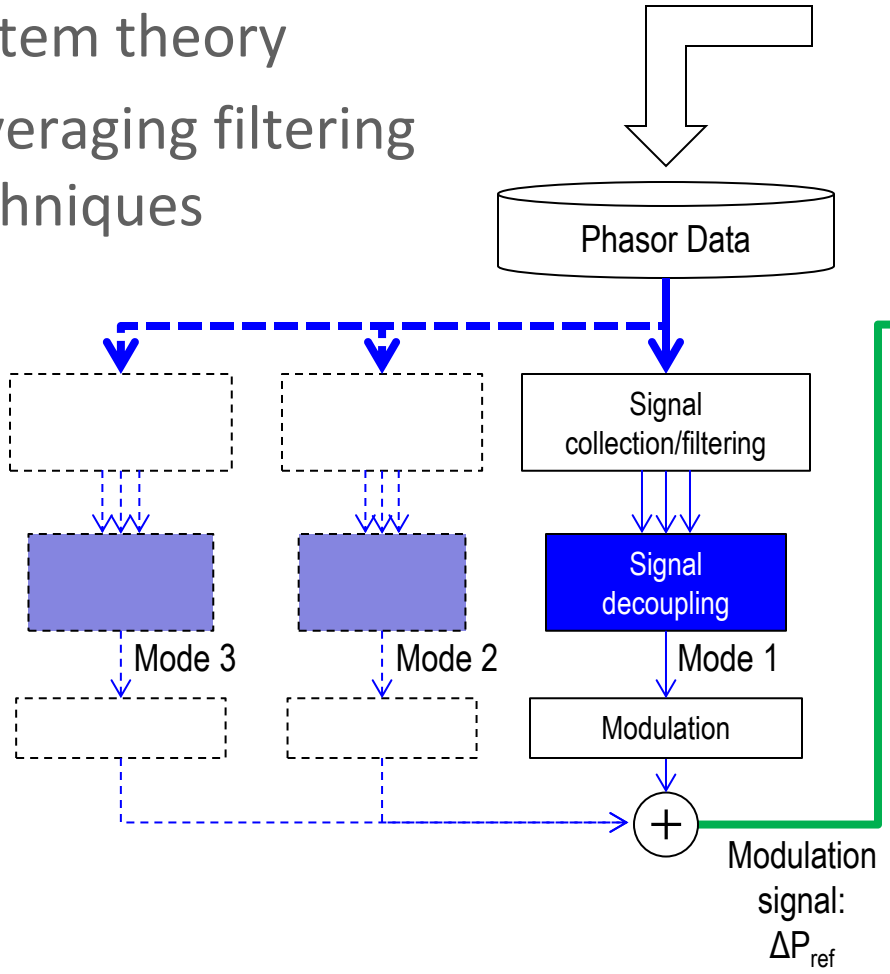


Problem formulation and objective

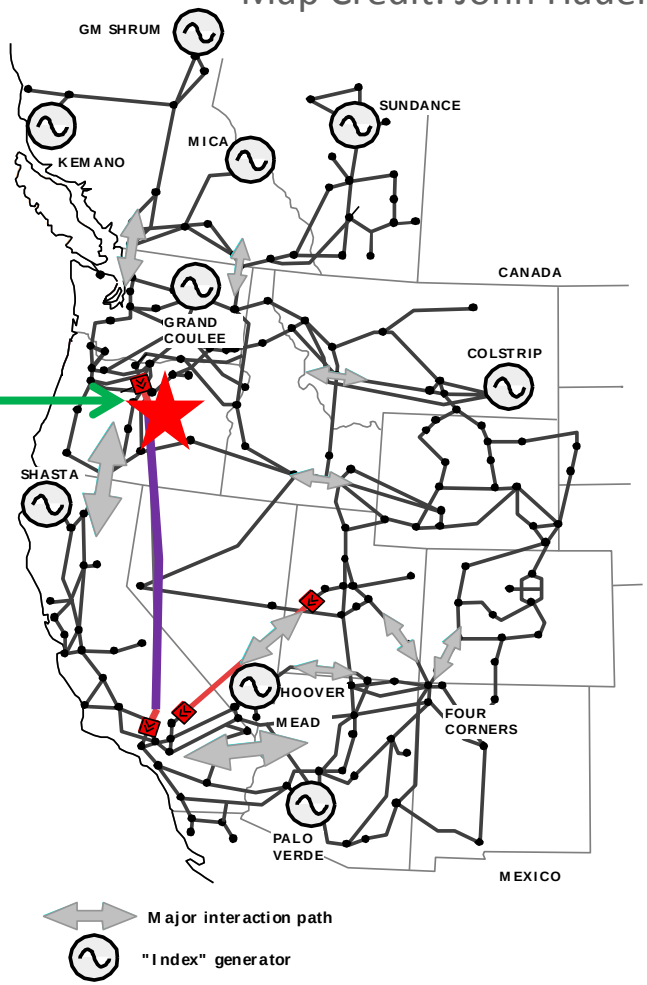
- Problem – interference of modes:
  - *Design Issue:* Signal selection is more complex and constrained by signal availability
  - *Design Issue:* Parameter tuning is more limited due to compromises
  - *Operational Issue:* Possibility of adverse impact on damping of one mode while improving damping of another mode
- Objective – minimize interference in modulation control:
  - Develop a modulation control that decouple the modes
  - Enable multiple modulation controllers, one per mode, at the same location
- Opportunities:
  - Wide-area phasor measurements
  - Available HVDC and FACTS devices, e.g. PDCI

Technical approach: decouple mode interference by decoupling signals

- Supported by linear system theory
- Leveraging filtering techniques



Map Credit: John Hauer



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Major accomplishments planned in FY15

- FY15 focus – Proof of Concept to answer the following questions:
  - How much is the interference?
  - How well can we decouple the signals in real time?
  - How effective is the decoupling in improving damping (non-linear effect)?
  - How well would multiple controllers work together (superposition)?
- A technical report will be delivered in May 2016.

Deliverables and schedule

#	Milestone/Deliverable	Target Date
1	Proof-of-concept studies of decoupled modulation control using simulated data with comparison against traditional modulation control.	11/30/2015
2	Development of real-time signal-decoupling methods to separate frequency contents.	2/29/2016
3	Technical report of the design of decoupled modulation control.	5/31/2016

Note: this is a new effort under CERTS, with a start date of 5/15/2015

Risk factors

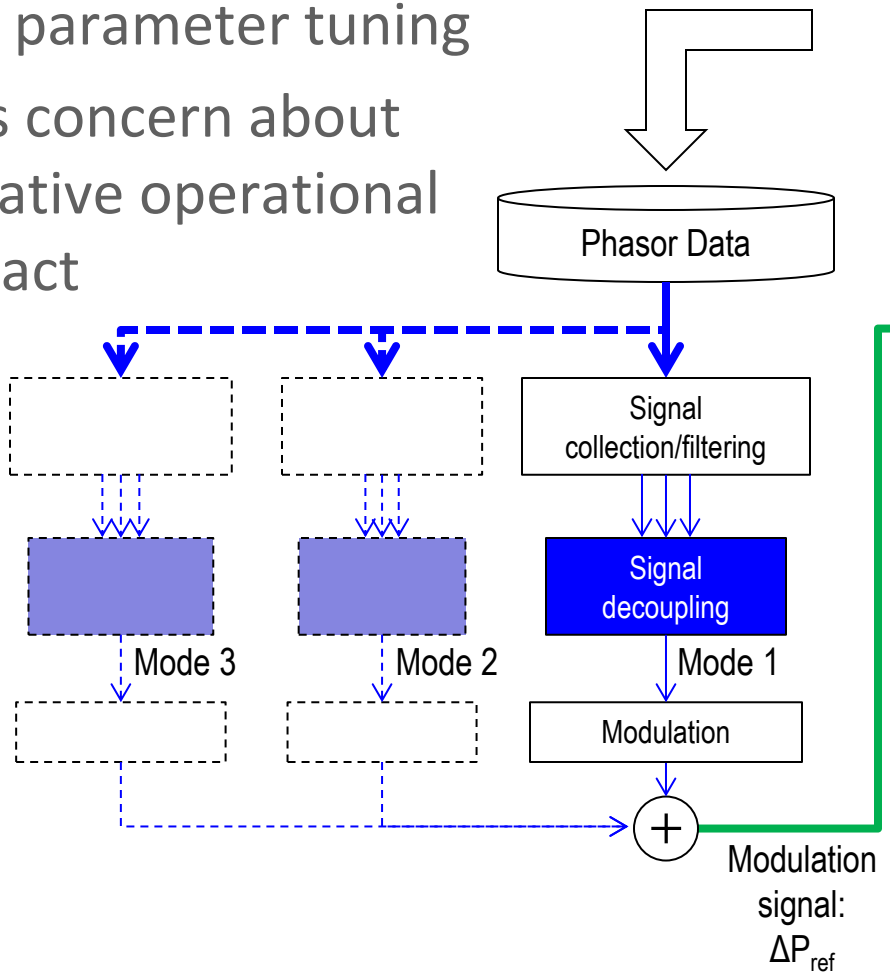
- Wide-area modulation design
  - Mitigation: leverage synergy with other CERTS efforts.
- Prototype testing
  - Mitigation: leverage probing testing efforts in WECC.
- Implementation
  - Mitigation: engage appropriate industry groups (e.g. JSIS) and stakeholders (e.g. BPA)

Follow-on work in FY16

- Design of decoupled modulation control based on decoupled signal contents
- Evaluation of decoupled modulation control with small- to medium-size test systems

Impact: Better damping with decoupled modulation

- Easier signal selection and parameter tuning
- Less concern about negative operational impact



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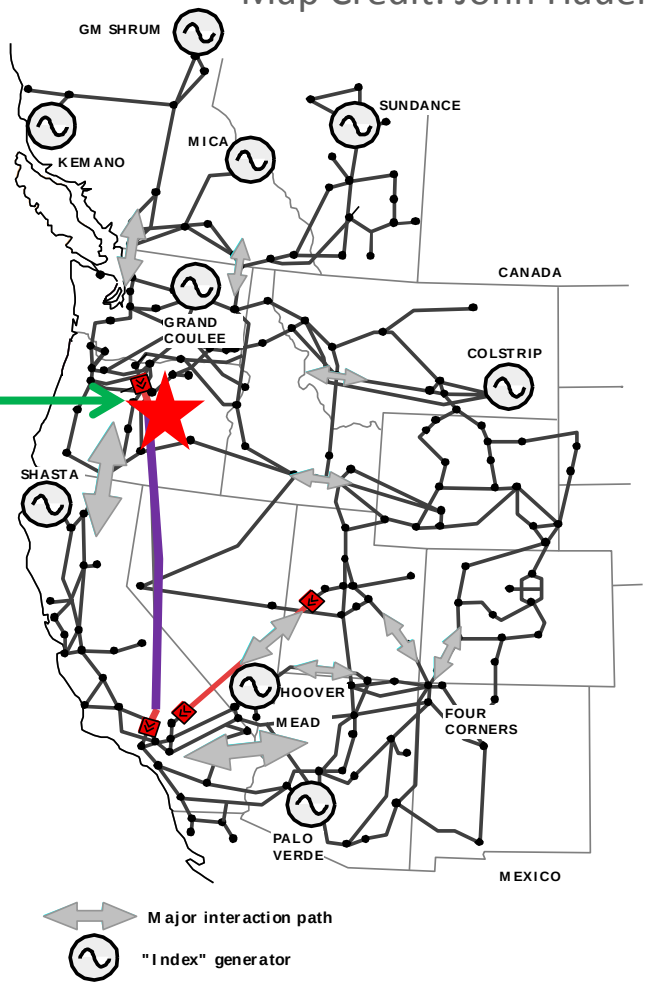

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